National Aeronautics and Space Administration
Goddard Institute for Space Studies

Goddard Space Flight Center
Sciences and Exploration Directorate
Earth Sciences Division

Use of GCMs in constraining climate sensitivity

Ringberg
March 2015

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NASA GISS

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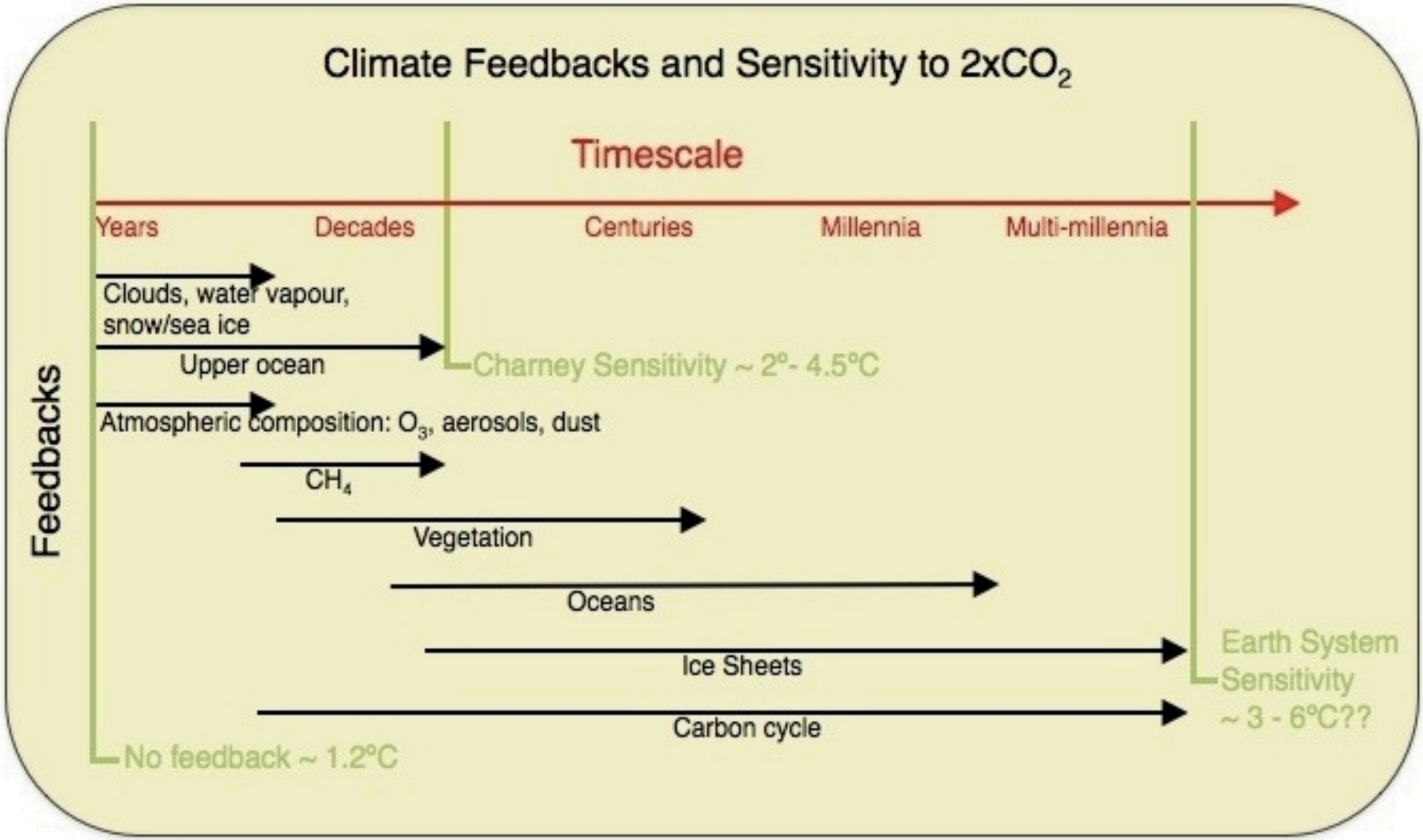
… and climate response...



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GISS-E2 Climate Sensitivities

GISS-E2 (Qflux) (NINT): 2.7ºC (Charney)

GISS-E2 (Qflux) (TCADI): 2.9ºC

GISS-E2-R (NINT): TCR=1.4ºC ; ECS=2.3ºC

Effective CS (Gregory): 2.1ºC

GISS-E2-R (TCADI): TCR=1.6ºC ; ECS=2.4ºC

Effective CS (Gregory): 2.4ºC

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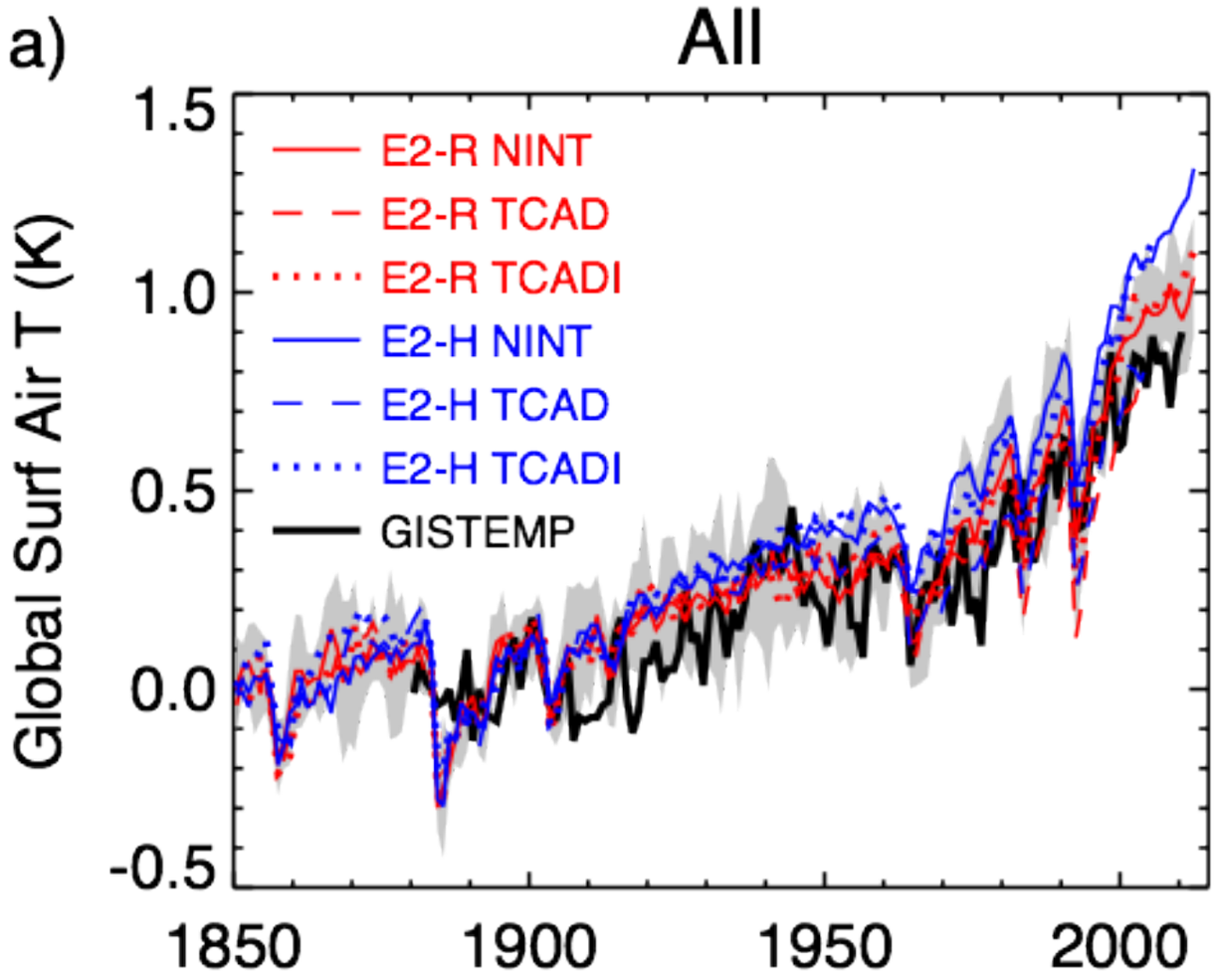
Historical forcings by concentration

WMGHG: CO2, CFCs, HFC, N2O
CH4 (incl. stratospheric water vapor)
Ozone: tropospheric and stratospheric
Anthropogenic Aerosols: SO4, NO3, BC, OC
Indirect Effect: Tuned (~ -1 W/m2)
Land Use/Land over: Crops/Pasture

Solar (incl spectral irradiance)
Volcanic: Aerosol Optical Depth



Miller et al, 2014

All forcings also used singly in 5 member ensemble

Do forcings add linearly?

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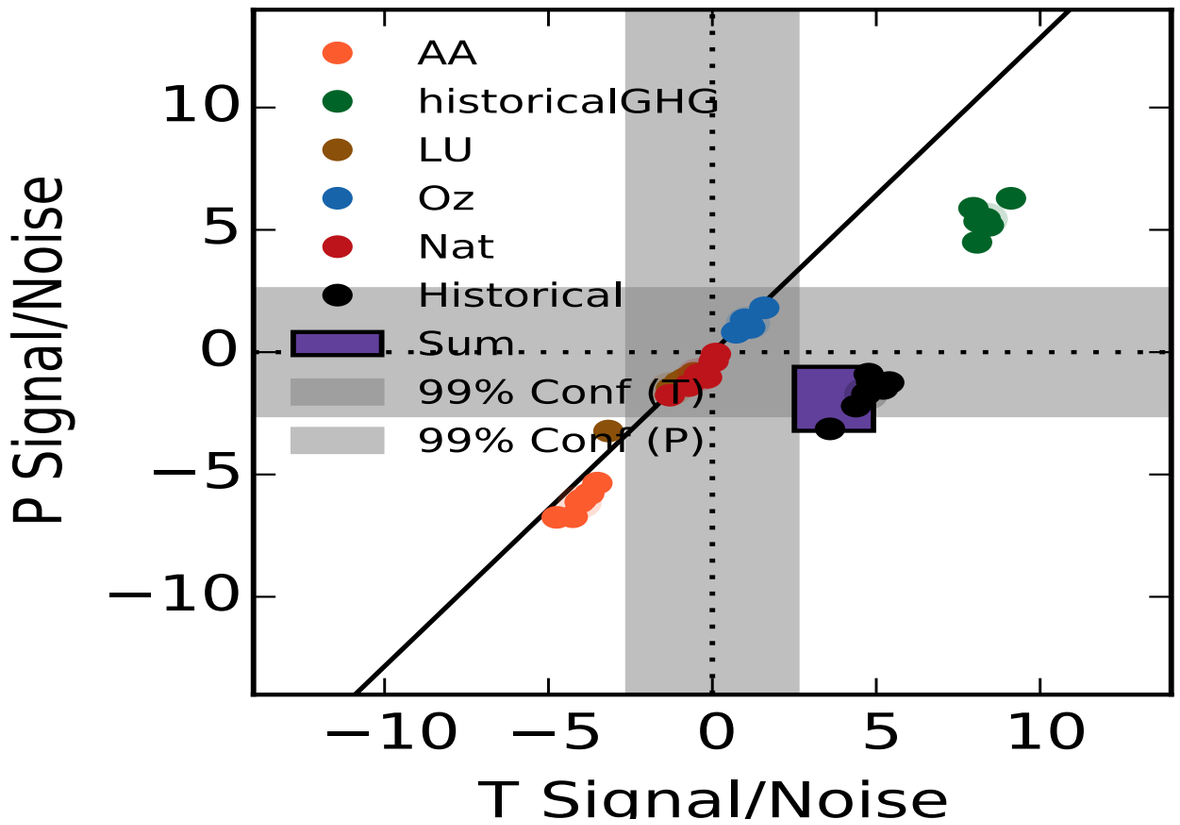
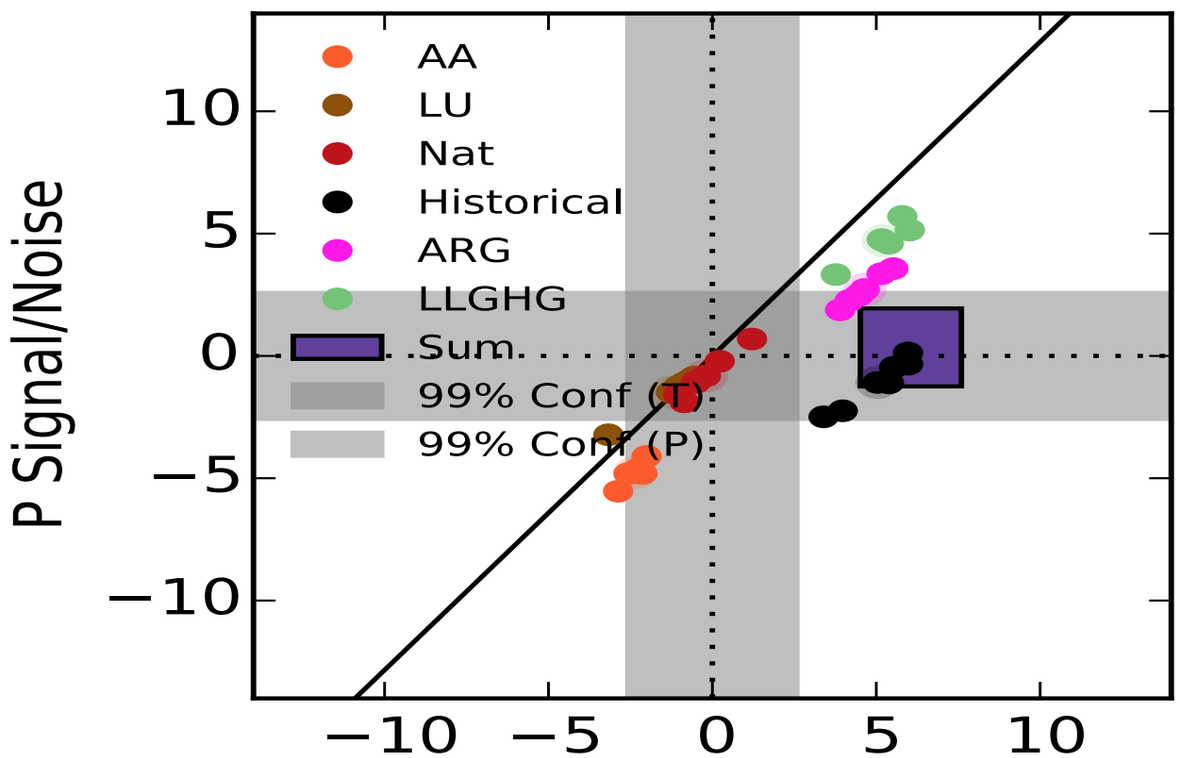
By concentration



By emissions



Marvel et al (subm)

Irrigation as an historical forcing

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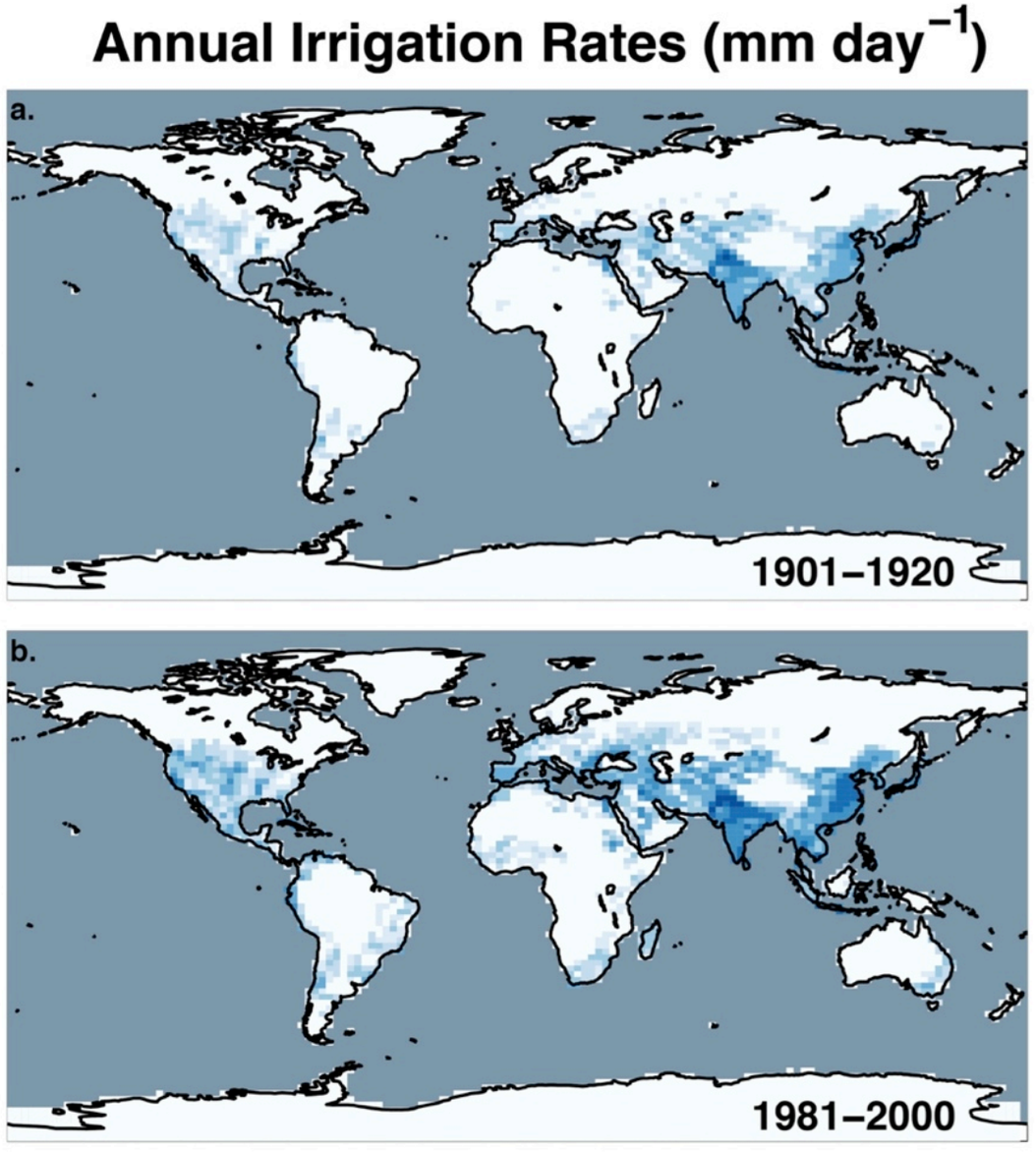

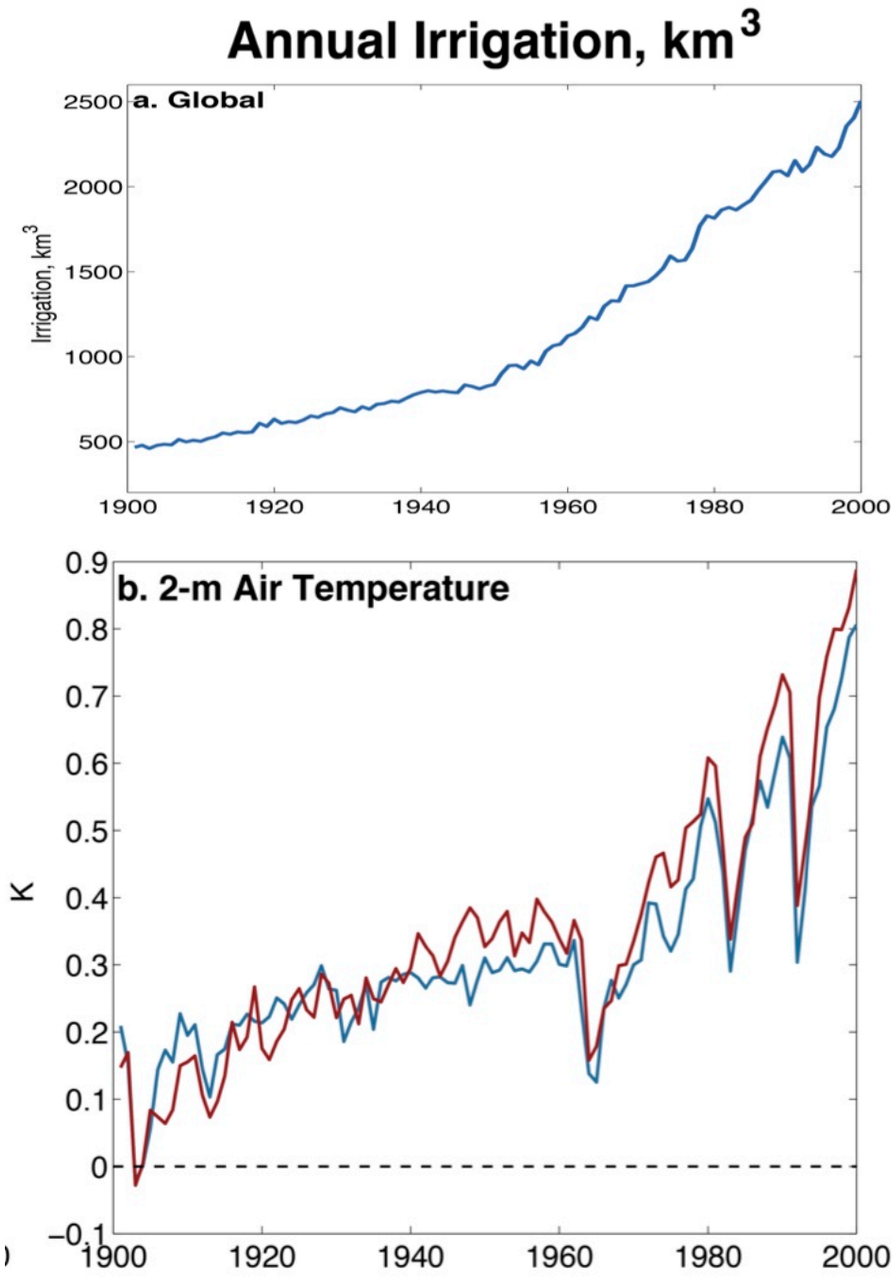

Irrigation applied based on historical data.
Large-scale cooling (More LH, less SH)

Cook et al, 2014

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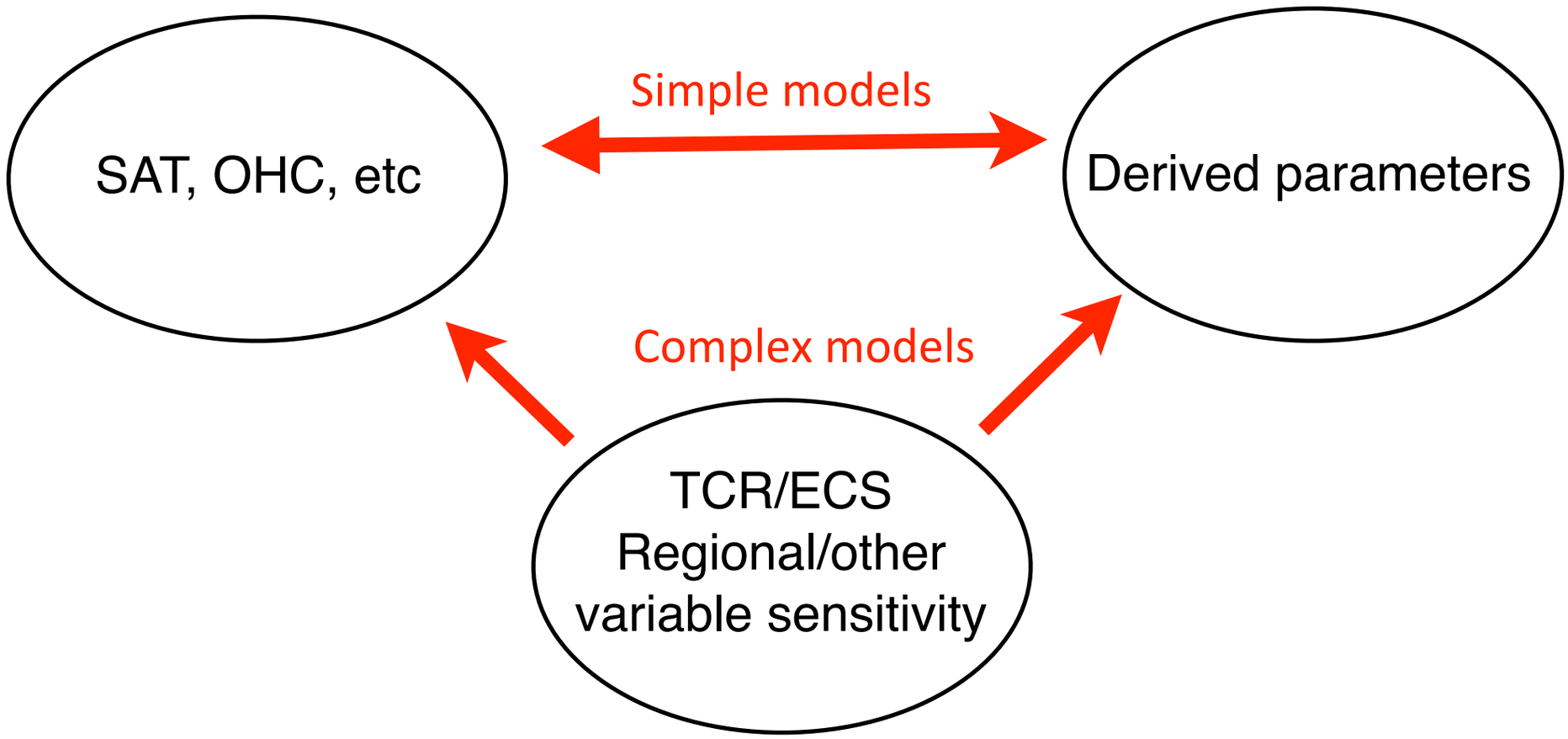
What is the role of GCMs?

(Collectively) as ‘expert prior’ (not pdf)
Estimates of forcings
Estimates of mapping between observables, derived parameters and actual emergent properties.



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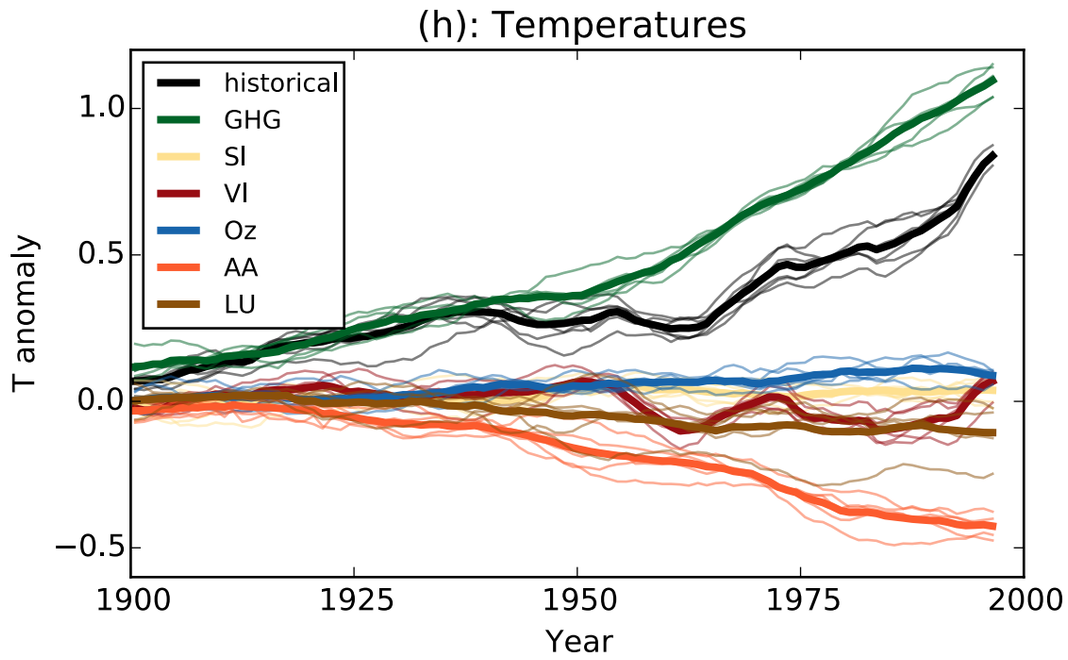
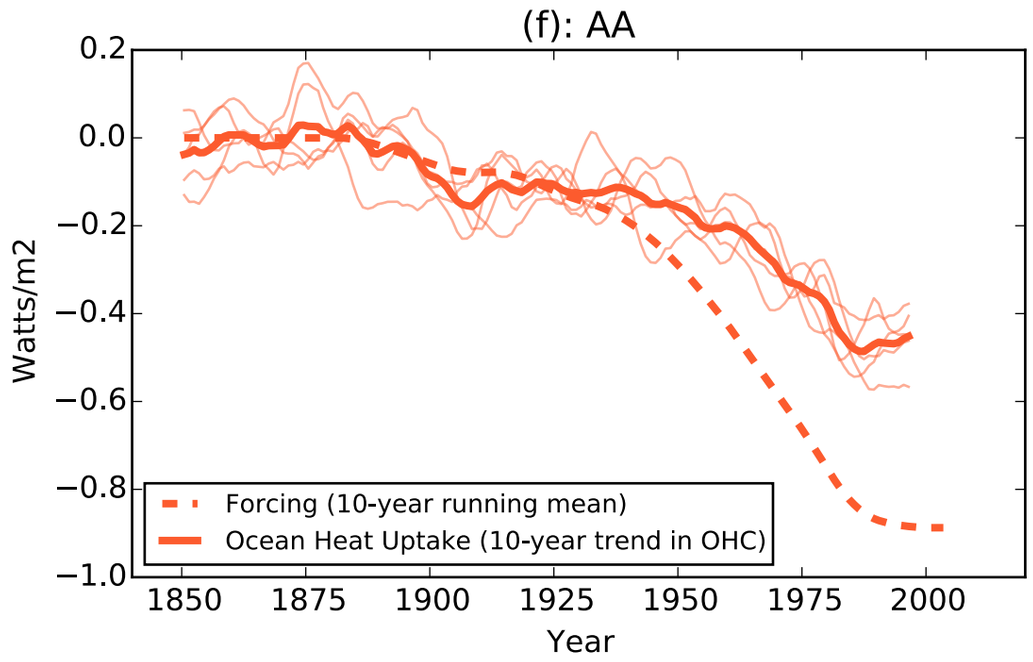
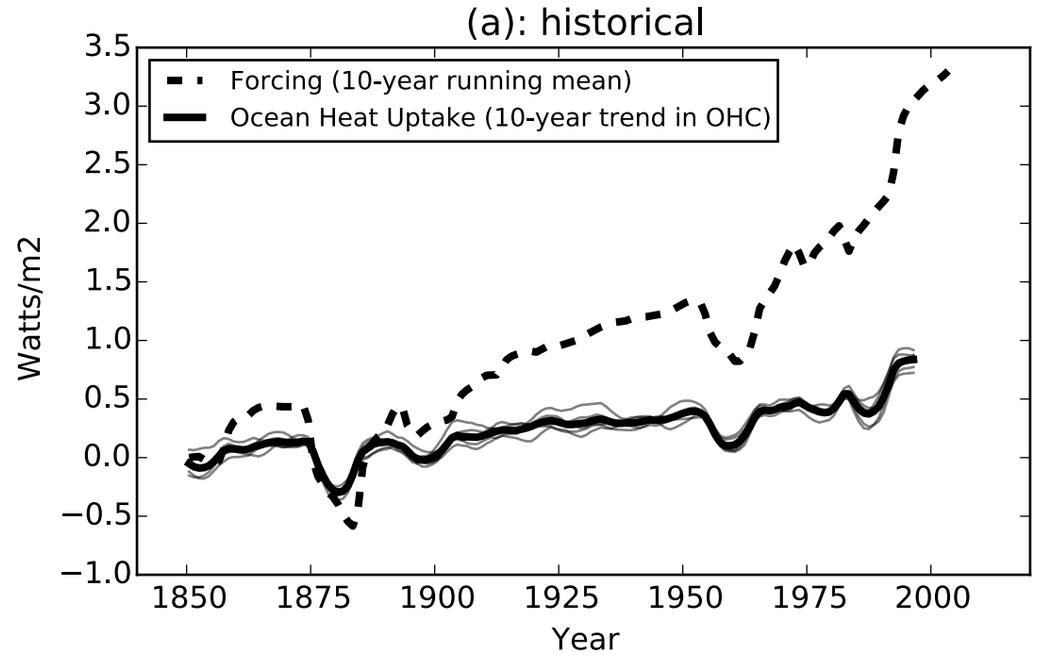
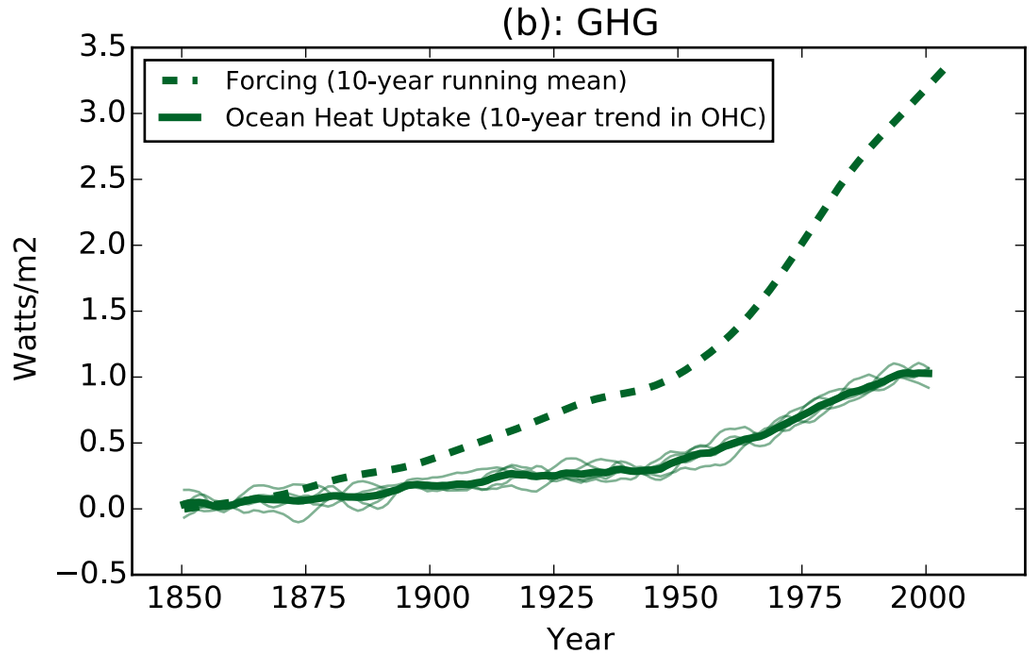
Single forcing runs CMIP5 GISS-E2-R









Marvel et al (in prep)

Perfect model framework

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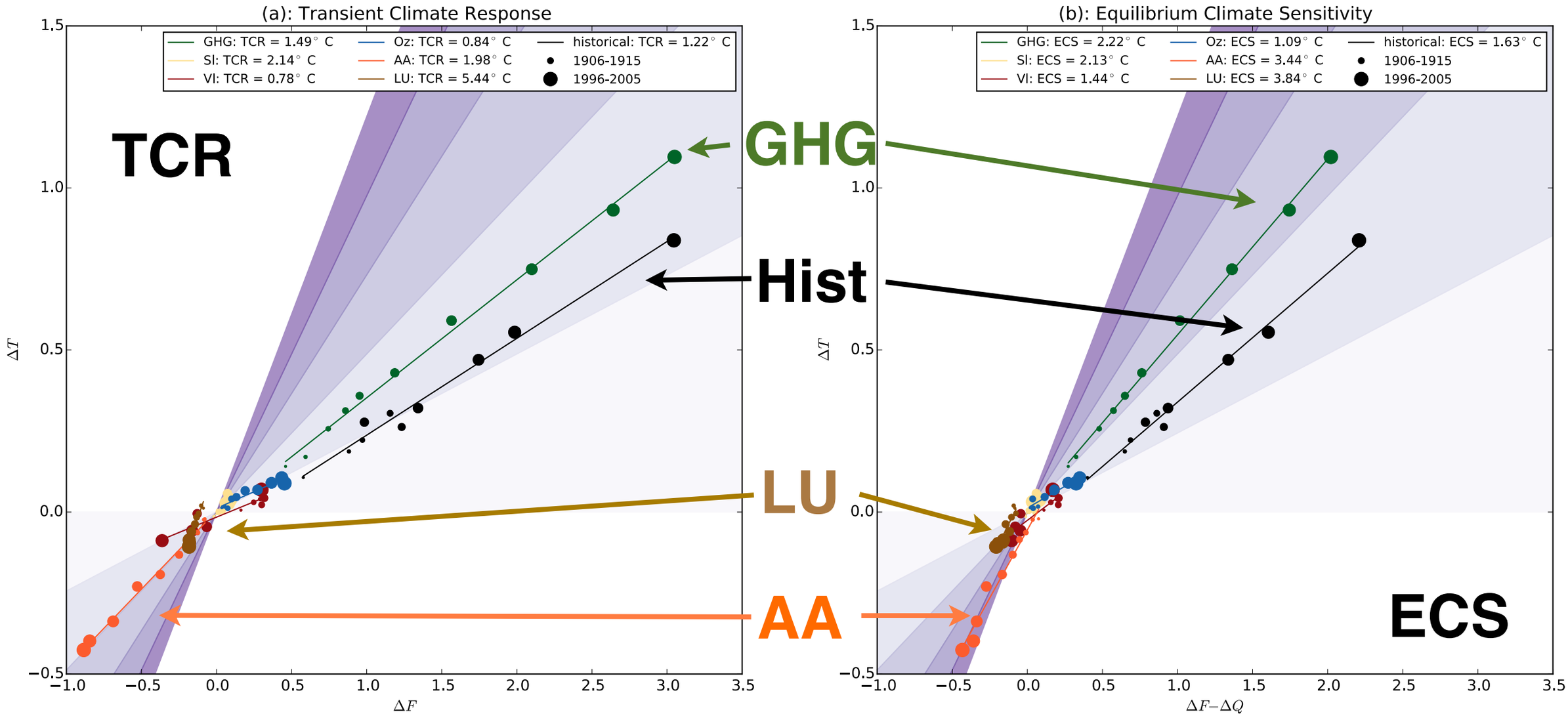
Known OHC, SAT, Forcing => defn. $\lambda_{TCR/ECS}$ from

$$\Delta F = \lambda_{TCR(ECS)} \Delta T (+ \Delta Q)$$

$$\Rightarrow TCR = \Delta F_{2xCO2} / \lambda_{TCR} \; ; \; ECS = \Delta F_{2xCO2} / \lambda_{ECS}$$



Marvel et al (in prep)

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Summary of inference from single forcing runs (GISS-E2-R)

Forcing	TCR (ºC)	ECS (ºC)
GHG	1.5	2.2
AA	2.0	3.4
LU	5.4	3.8
Oz	0.8	1.1
Historical	**1.2**	**1.6**
Actual	**1.4**	**2.3**

Forcings add vectorially in $\Delta F/\Delta T$ space

Marvel et al (in prep)

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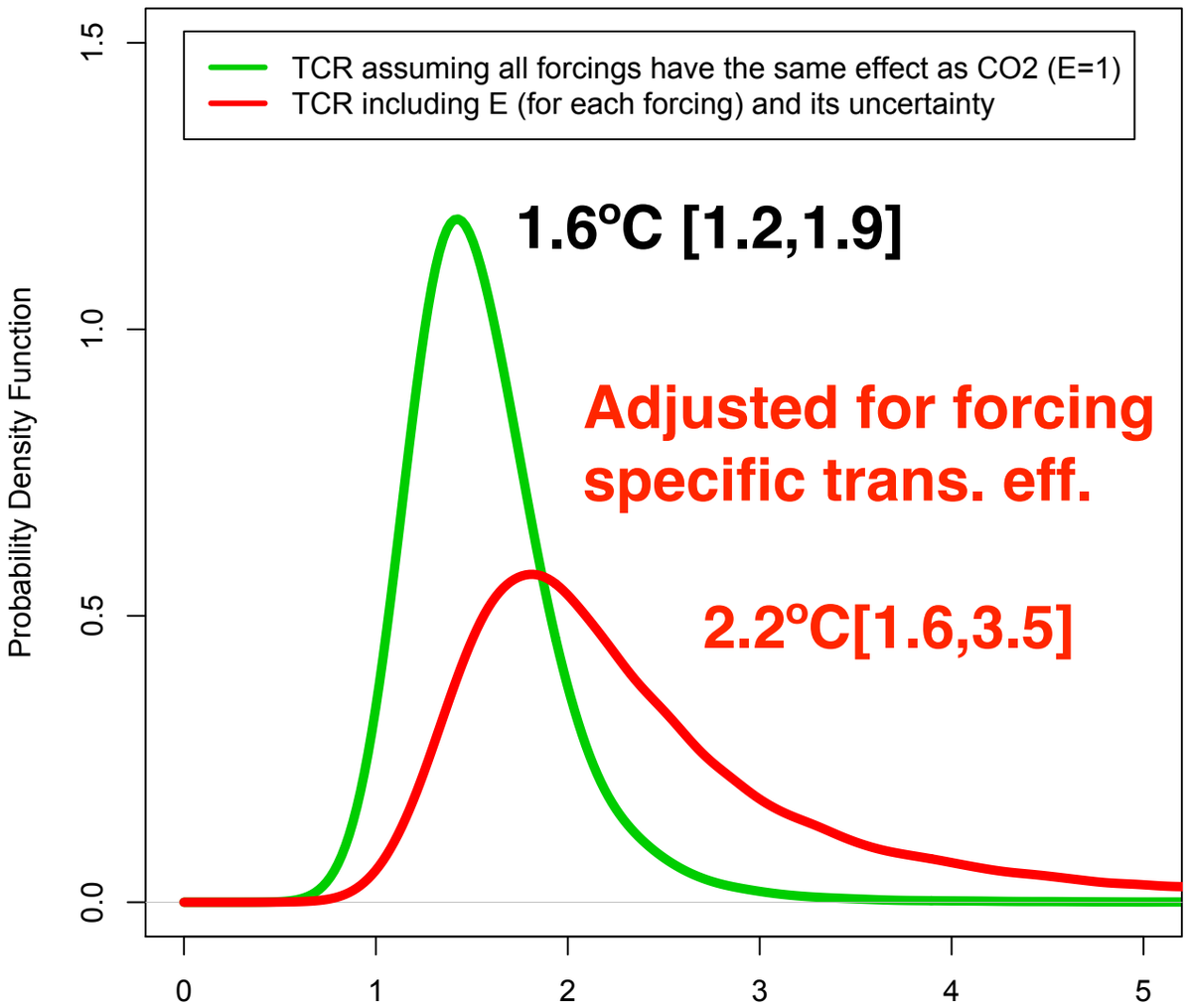
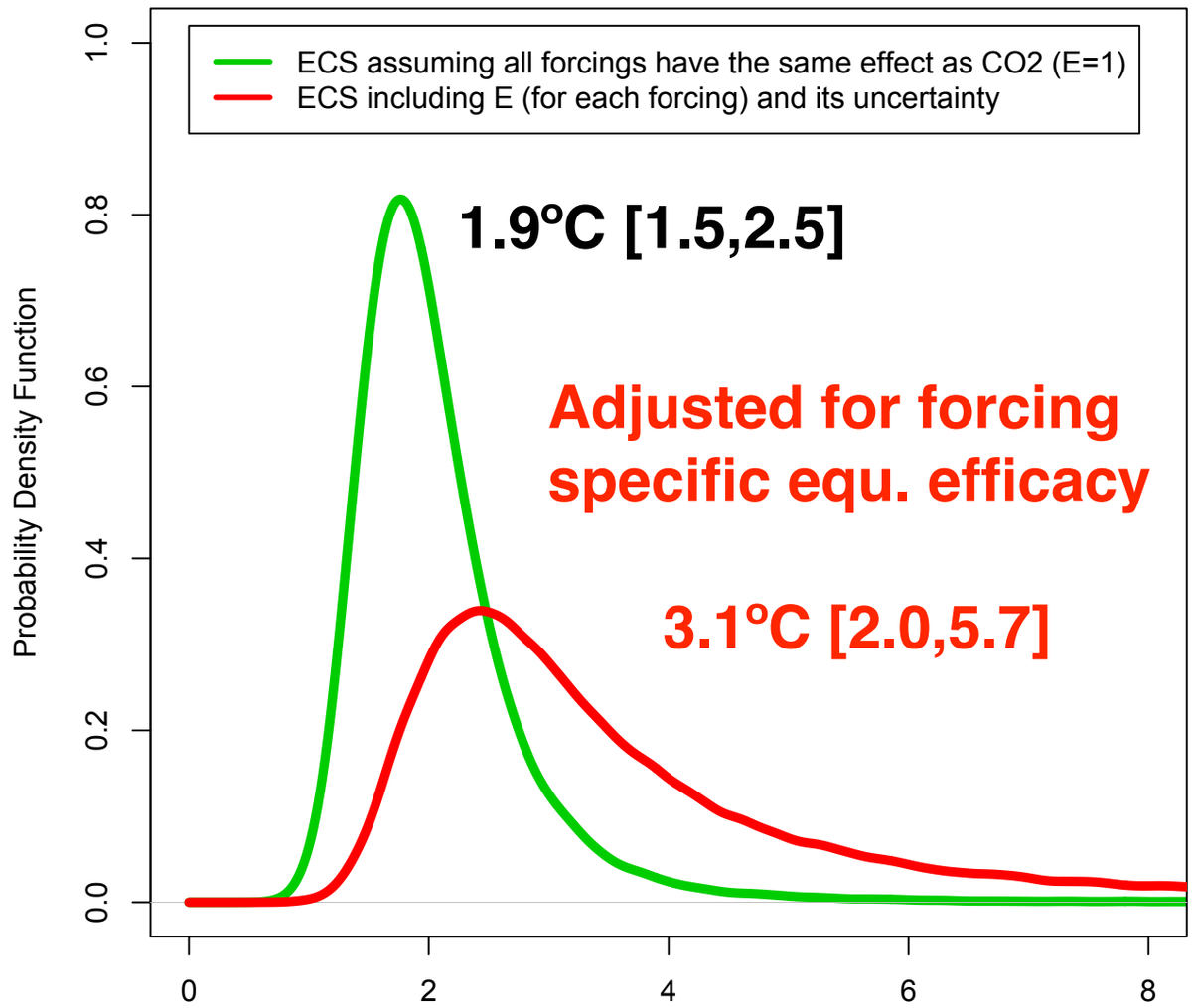
PDFs from historical record adjusted by single-forcing results

TCR



ECS



***Median, 17-83% range**

Uncertainties in E derived from ensemble spread

Marvel et al (in prep)

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Conclusions

TCR/ECS constraints based on historical transients are biased low.

Results from GISS ModelE suggest that this is related to higher efficacy of aerosols and LU

Accounting for this largely reconciles historical period estimates with paleo spread.

Even if a single model not definitive, not basis to assume E_i=0 with no uncertainty.

Increase in median TCR/ECS ~ 35-60%